An application of ELECTRE Tri to support innovation

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Abstract. In relation to the economic crisis, the airports were pressed from their national Civil Aviation Authorities and from the market to lower their costs and improve their capability in organizing the supply of public facilities. Some airports reacted to this situation improving their efficiency in invoicing and collecting user charges. An enterprise, that supplies different services to the Italian Aviation Authority and to several Italian companies who are airport concessionaires, decided to analyse the Italian airport revenues from off-flight services, in order to compare their different results and help them improve their product offerings and identify new products' value drivers.

To meet this requirement an outranking method, ELECTRE Tri, was used to evaluate the marginal and overall activation of each Italian airport in reacting to the crisis and making profit by organizing public facilities and services that are different from the classic air navigation services on the ground. The choice of the method and the adopted procedure was motivated by the difficulties in reliable data acquisition, comparison of different and almost incomparable situations and preference elicitation, without the involvement of the actual decision makers and in relation to a sequence of model versions, different in terms of problem structuring and parameters definition.

A collaborative procedure of model structuring and incremental result analysis and several ELECTRE Tri applications, assigning each airport to a specific category, were oriented to the generation of a "robust" model and a clear result, to read and synthesize all the information elements, understand the situation and acquire a shared vision of the problem, orient the process of information acquisition and support the definition of some improving actions.

Keywords: model structuring, model robustness, preference elicitation, banchmarking.

Introduction

The 2009 annual IATA report declares "Air transport will be a smaller industry for at least the next few years. The challenge is to reshape and resize for profitability." In relation to the financial and economic crisis, the airlines activated new environmental responsibility, safety and security strategies but at the same time policies that were above all oriented to simplify the administrative activities and reduce the costs. Several governments tried to use taxation to control the processes and in some cases launched stakeholder consultations on how to strategically shape the sector, from economic regulation to infrastructure improvement.

The airports were pressed, from both the national Civil Aviation Authority and the market, to lower their costs and improve their efficiency in airport operations and performance monitoring and in invoicing and collecting user charges. Some airports reacted improving their capability in organizing their supply of public facilities, such as parking sites, car rental, duty free, shops, restaurants and bars, but also of specific off-flight services, such as mobile rental facilities, wireless access, business centres and so on. They motivated their decision with the impression that these non-core services could make more revenue than the classic air navigation services on the ground.

A small but lively enterprise, that supplies different services to the Italian Aviation Authority and almost to all the Italian airports, realized that the Italian airports could be helped to improve their product offering and to identify new products' value drivers. Therefore they decided to elaborate an analysis of the Italian airport revenues from the non-core services, that in Italy are defined "non-aviation" services, starting from the Annual Reports and Balance sheets of the companies that manage the airports. The aim of their analysis was the comparison of the different performances, a sort of benchmarking of the companies, to be used with the clients in order to underline their "apparent" weakness points and to activate a deeper analysis, to better describe their situation and to elaborate new strategies.

The data quality and usability were perceived as the first obstacle to the analysis. Annual Reports and Balance sheets propose data that are official but not homogeneous, informative in some cases, but too concise and/or not always reliable in others. The web sites of the airports in some cases are detailed and rich of easily available information, in some others information is difficult to be extracted and substantially poor. And an evaluation model has to deal with all the actions (the companies in this case) in the same way.

A second problem emerged from the first analysis of the data. The airports in Italy are really different, not only in terms of whole dimension but also in relation of the traffic typology. A comparison of so different and almost incomparable situations should require specific attention and the use of a statistical method to cluster the airports in terms of revenues from their non-core services could re-produce the same typological distinction.

In relation to these problems, the application of an outranking method, ELECTRE Tri, was proposed in order to avoid the direct comparison of the analysed airports and to use data from different sources and multiple criteria models with thresholds, that limit the impact on the result of the data uncertainty. ELECTRE Tri is a sorting method with a multiple ordered reference set. Ordered categories are defined by reference profiles (i.e. combinations of values on the family of criteria) and the analyzed actions (in this case the airports or the companies that manage the airports) are not compared between them but with the profiles and then assigned to the categories.

Another order of difficulty is present and has to be associated also to the application of ELECTRE Tri to the problem. The consultancy company is the problem owner, but not the decision maker. They do not require a statistical method to analyse the whole situation, that they understand. They would assume a decision aiding role in relation to their clients' decision problems and need a tool that could facilitate communication with their clients, the actual decision makers, and also with new potential clients. Therefore models and applications of a decision aid method have to be developed with the direct involvement of the consultancy company, in relation to future decision processes that should produce new strategies or at least innovate old procedures. The activation of new strategic decision processes, by means of the present analysis of the different related aspects and of the future involvement of the actual decision makers in model structuring and preference elicitation, was considered the specific aim of this work.

When the preference system is not "accessible", model structuring and preference system elicitation are possible using an approach that was developed during an intervention of action research in a public administration (Norese, 2009; 2010). Some models and applications of ELECTRE Tri to these models were developed in a step-by-step procedure and oriented not towards a solution but towards a collaborative analysis. The decision maker was always present, but was not willing to be involved in a constructive approach to the model building and preferred an "accompanying" role with a constant analysis of all the knowledge elements that were acquired. Experts and actors of the decision process were involved in activities of conceptual model structuring, validation and re-structuring, of result analysis and consequent improvement of the model parameters, of data analysis and validation of the evaluations, arisen from these data, or data re-organisation. The first models were very simple but step-by-step they became adequate to deal with all the aspects of the problem and all the different kinds of information that were acquired or produced. All the steps of the work were oriented to create a communication space and to improve and validate this incremental course of action.

A similar incremental approach was used in this case and a step-by-step procedure was developed in interaction with the consultancy company. The context and the actions that generated the analysed problem, the motivation of a new approach and the model structuring process are described in the first section, with the main aspects that a mutual learning process analysed by a visual reading of the model structures.

In the second section, the model parameters, starting from information and knowledge elements that were used to elicit preferences, and the different roles and results of the ELECTRE Tri applications are described, together with the devices that had to be adopted to guarantee robustness of both the models and the results. Some elements about the future use of these results and the future developments of this application are synthesized in the conclusions.

1 **The problem context**

The consultancy company does not know the ELECTRE methods and Multiple Criteria Decision Aiding (MCDA) and is interested in acquiring competences in model development and using methods. At the same time they clearly perceive the main problem of this case, the limits of the official data that can be acquired from internal regulations and standards that they often criticize and sometimes contribute to improve, and their need of actually knowing the different capabilities of the Italian airports in organizing their supply of public facilities. They could support them by a clear representation of both the Italian whole situation and a specific identification of strong and weak points of each company who manages an airport.

The airports are not homogeneous in terms of dimension and traffic, nature of the traffic control management and the passenger assistance services. A study, that was developed by OneWorks, Kpmg and Nomisma for the Italian Civil Aviation Authority and proposed in synthesis in some newspapers (see for instance Il sole 24 ore, 7/18/2010), tend to classify the different airports in categories such as strategic, of prime importance and complementary airports. A comparative analysis of their different results in making profit by organizing public facilities and other off-flight services could produce a trivial ranking, with the bigger airports in the first positions and the smaller in the last ones. A different methodological approach has to be used to distinguish the different activation potentialities of the Italian airports.

Therefore we started structuring a first multiple criteria model, to analyse the capability of each structure of airport service to organize air navigation services on the ground and traditional services for the passengers, with the aim of using an outranking method, ELECTRE Tri, to evaluate and assign each airport to a sequential category (such as Strategic airport, Airport that presents elements of prime importance and Airport that develops only simple and limited activities, or High, Medium and Law capability). A second model was developed to analyse the different financial results of non core activity management, in order to assign the airports to some sequential categories of performance, using again ELECTRE Tri, and then correlate the performance of each airport, that resulted from the second model, with its capability level, from the first one.

This choice is motivated by the need of clearly recognizing the functioning of each specific airport, in terms of non-aviation services, but also because the consultancy company, that supplies different services to the Italian Aviation Authority and almost to all the Italian airports, has a good knowledge of this context and above all knows the whole quality of each airport service structure. This knowledge is the core issue of the first model because only the context knowledge can produce significant and consistent model elements (Tsoukiàs, 2007).

Several applications exist in literature that analyse standard air services (se for instance Adler and Golany, 2001; Adler and Berechman, 2001; Graham, 2005; Martín and Román, 2008; Morrison, 2009) and cluster the airports in terms of efficiency of these services (Sarkis and Tallur, 2004; Zenglein and Müller, 2007; Adler et al., 2009; Martin et al., 2009, Volkova and Müller , 2012). Data Envelopment Analysis (DEA) is often used, alone or combined with methods of statistical analysis.

For non-aviation services the literature is quite limited (see Reiss, 2007; Barros and Dieke, 2008; Yang, 2010; Curi et al., 2011; Fuerst et al., 2011; Fasone and Maggioli, 2012) and proposes case studies, data analyses in relation to specific airports and proposals of indicators for benchmarking studies that are a useful support in the activity of parameter definition.

Very few applications in the “business airport” context present multicriteria analyses that are not limited to DEA (see for instance Vreeker et al., 2001; Pels et al., 2003; De Brucker et al., 2011; Postorino and Praticò, 2012). They are interesting but not so consistent with our decision problem.

We started from the consultancy company specific and whole knowledge of each airport service structure, in order to understand their way of thinking and to propose our way of synthesizing all the different concepts that they consider significant.

Model structuring and formal definition of a consistent family of criteria are the first and most arduous tasks in MCDA modelling. An incremental approach is useful because the problem owner and the analyst have to acquire a common language and use it at first to identify structural concepts that introduce the main strategic aspects and the model dimensions, and then can analyse together the available data that are related to these dimensions. A collective data analysis is essential in order to understand which are the criteria that could adequately “express” the identified logical dimensions and which are the evaluations that could be used in the different criteria.

A previous or a simultaneous use of a visual tool is essential to visualize the main concepts of a problem. Cognitive maps and/or decision trees are often used with this aim. These tools allow a mutual learning process to be activated and an incremental sequence of possible logical structures to be analysed in the course of action. When the model framework and the nature of the criteria are acquired as elements of a shared knowledge, the formal definition of the model, with the required parameters, becomes almost easy. This incremental learning process, that involves problem owners and analysts, facilitates the parameter definition and allows the decision makers to perceive the meaning of each model component and to understand if inconsistent elements are proposed in the decision context and process (see Norese, 2006a).

An incremental approach to model structuring and formalisation, with sequential steps of modelling and shared validation, is even more useful when the decision problem is complex because it is unusual or so new that experts or references from literature are nor available, or the problem owner is not the decision maker nor the end user of the model (Norese, 2006b; 2010).

In relation to the analysed case, an incremental structuring approach can be usefully activated structuring a model in relation to a first context that is well known for the consultancy company, as the capability model of the airport service structure. This first step can simplify the acquisition of a common language and make less difficult the approach to a second problem context and model (in this case about the non-core service performances) that require knowledge that is not easily available, above all in a structured form, without the involvement of the actual decision makers in the modelling process (today impossible for the consultancy company).

Not only the structuring phase but also the result analysis, after the ELECTRE Tri application to a first “easy to understand” model, have to be developed in a communication space, between the consultancy company and the analysts and, in the future, between the company and its clients. The result analysis is used to validate result and model, or to improve the model, activating a new cycle of the learning process that is facilitated by a new ELECTRE Tri application.

Each modelling hypothesis formulates the decision problem and context (Roy, 2007) and the evolving structure of the model, together with a clear representation of the formal model and the ELECTRE Tri results. All these elements are important in the decision aiding intervention. In this case, they are essential in the operational relationship between the consultancy company and the analysts, and will be the basis to create a formal interaction with the actual decision makers, in a new process of organizational learning, with a “true” preference system for a new model development and implementation.

1.1 **The model structuring process**

A visual reading of the model structure was used to facilitate the consultancy company’s introduction to the distinction among data, criteria and conceptual elements that define the structure of the model. The first structure of the model *Capability of the airport system* included two conceptual dimensions (Services and facilities, the first, and Traffic dimension, the second). In relation to the first dimension, three criteria were proposed (Air terminal facilities, Commercial area services and Base services). In relation to the second dimension, only two criteria were firstly proposed, Passengers (per year) and Active companies, that provide passenger and/or cargo flights.

The first simple structure was discussed, criticized and improved. Five different structures were elaborated and discussed in sequence. Two of them are proposed in figure 1 by means of the decision trees that were used to discuss the structures, with a visual distinction between conceptual elements, criteria and data.

Three conceptual dimensions were proposed in the second structure, one more than in the first, and the criteria became eight. But this evolution of the first structure again presented only one level of conceptual model disaggregation. At the end of this evolution process the last structure was totally different, with two or three levels of logical definition of the structural concepts, before the criteria generation.

The trees were used both as visualization of the model framework and as a tool to orient the data acquisition process. All the available data that were considered usable, in order to elaborate an adequate evaluation, were listed below each criterion. In some cases the evaluations were directly referred to the criteria names, in the others a data treatment (combination or addition) was discussed. Figure 1 underlines and distinguishes the two situations. The lists of the required data are not indicated when criteria, evaluations and units of measurement are expressed in the same way (such as for the criterion Passengers per year). The distance between the second and the last structure of the model is evident also in relation to the different use of the data. At the end only one criterion requires a lot of data, the other evaluations are direct or synthesize two or three kinds of data.

Several possible sources were considered in the structuring process, not only Annual Reports, Balance sheets and web sites of the airports. The airport internal documents, with regulations and standards, resulted useful to obtain information about the level of the supplied services and the web sites of the national Civil Aviation Authority (ENAC) and the Italian Transport Ministry to obtain data about structures (such as parking space and landing strips) and commercial traffic characteristics.

The last model structure of figure 1 produced the model that is synthesized in table 1. The Capability of the airport system is expressed by fourteen criteria in relation to the dimensions Traffic management, Air navigation services on the ground, Public facilities and Accessibility. Nine criteria use cardinal scales, with specific units of measurement, and data from the ENAC web site (g_2, g_3, g_4 and g_5) or the internal regulations and standards of the airports (g_6, g_7, g_8, g_{10} and g_{11}). The other five criteria use ordinal scales with evaluation states resulting from combinations of data (see tables 2, 5 and 6) or directly elaborated and described in tables 3 and 4. The data are deduced from the internal regulations and standards and the web sites of the airports, plus the web site of ENAC (g_1), or plus Annual Reports and Balance sheets (g_9 and g_{13}), by a direct evaluation (g_{12}) or from the web sites of the public transport services, using the links that are present in the airport web sites or by a direct analysis (g_{14}).

Structuring the model *Performances of the non-aviation services* required less time thanks to the experience and common language that were acquired during the long phase of the first model structuring. In figure 2 the three structures that were elaborated in sequence are proposed by means of the same decision trees that were used for the first model.

The last structure produced the model synthesized in table 7, that includes two dimensions (Entrepreneurial skills of the company, in terms of revenues from investments, and Answer to the demand of non-aviation services) and seven criteria. All the criteria use cardinal scales, in Euros when specific revenues are evaluated using Annual Reports and Balance sheets (of the year 2008) as sources (g_1, g_2, g_3, g_4 and g_5), or by indirect indicators (number of car rental companies that operate in the airport, for g_6, and number of bars, restaurants and other catering services, for g_7) when Annual Reports and Balance sheets do not propose enough homogenous data and the data are acquired from the web sites and the internal documents, with regulations and standards of the airports.

2. ELECTRE Tri to facilitate a collective modeling process

ELECTRE Tri (Roy and Bouyssou, 1993; Yu, 1992) is a sorting method which allows an *action* to be evaluated according to multiple criteria and, in relation to its absolute merit, be assigned to one of the k pre-specified ordered categories: C^1 (the worst), ….., C^k (the best). Each C^j category is limited by two reference actions (profiles), its upper and lower limits. Each evaluated action is compared to all the ordered profiles and assigned to one category in relation to the results of these comparisons.

All the parameters of a model for ELECTRE Tri (the reference profiles, the thresholds that characterize pre, quasi or pseudo-criteria, the importance and veto power of each criterion and the cutting threshold) have to be defined in an explicit and transparent way. The decision makers have be involved in a collective modeling process, and often experts and actors have an important role. The constructive learning which is proposed in (Dias and Climaco, 1999 and 2000; Dias et al., 2002) can support a step-by-step definition of the parameters.

In this case a constructive learning process was activated above all to facilitate a consolidation of less or non-structured knowledge elements and therefore an easier interpretation and understanding of the behaviour of the different airports, in order to define specific decision aiding contexts for the future. Essential aim of the process was the development of transparent and "robust" models, able to include and synthesize different knowledge elements, to be analysed, validated and improved both during the development process and in the future, and to propose reliable interpretations of the examined situation.

ELECTRE Tri was used in this modelling process in order to test parameters and modelling hypotheses. The model parameters were iteratively defined, criticized and improved, while several applications of ELECTRE Tri were developed and the results analysed with the consultancy company. The description of this modelling process, with several revisions and a sequence of new ideas, is not so simple. Some parameters were easily defined. Thresholds of indifference, preference and veto, number and nature of the categories and reference profiles were proposed by the analysts and then discussed with the consulting company who accepted all the proposals.

The definition of the weights (that in the ELECTRE models are the coefficients of the criteria relative importance) was more difficult and the adopted procedure of direct elicitation and a tentative of parametric inference are here described in detail in 2.1. Other key steps of the process were the definition and use of the reference profiles and the robustness analysis, that was more oriented to test the model than the result robustness. These steps and the framework that was used to synthesize the results of the last ELECTRE Tri applications to the models are proposed in 2.2 and 2.3.

2.1 **An iterative approach to define weights**

In relation to the first model, where all the Italian airports with at least ten thousand passengers per year were analysed, a first set of possible weights was expressed analysing with the experts the model structure, i.e. adopting a top down approach that attaches the same importance to the strategic elements of the decision tree first brunching and distinguishes the importance of the other conceptual elements or the criteria, moving along all the branch points of the tree.

The result of the ELECTRE Tri application with these weights was considered unacceptable by the consulting company and their expertise of the examined situation allowed some weak points in the expressed weights to be identified and reduced or eliminated. The importance of the dimension Traffic management was kept unchanged (0.36), but the distribution of the importance among the criteria was substantially changed in relation to g1, g4 and g5 (see table 8, Weights 1 and 2). The result of the new ELECTRE Tri application, with the improved weights, was considered acceptable, but its collective analysis suggested a marginal change of the weights (see table 8, Weights 3, g8,g9,g10, g13 and g14). The results of the ELECTRE Tri applications, in relation to these two weight variants, were analysed and used at the end, in the robustness analysis.

A similar approach was activated for the second model, but this time the definition of the weights resulted more difficult for the consulting company. The second model analyses strategies and results of the nineteen companies who manage the airports of the first model, in relation to some specific operational contexts (in two cases, Rome and Milan, only one company manages two airports).

The main branches of the decision tree that represents the model structure indicate two possible strategies of the company who could manage the airport maximizing the almost immediate revenues from new specific services or improving the entrepreneurial approach to the changing economy and therefore the investments. Without decision makers, analysts and experts cannot express the relative importance of these strategies and the relative criteria. Therefore three possible strategic scenarios were defined (50%-50% or neutral; 60%-40% oriented to the investments; 40%-60% oriented to the services) and a substantial equal importance of the criteria that were linked to each strategy was accepted by the consultancy company (see table 9). A different strategic scenario and a tactical distinction of the criteria could be defined in the future interaction process between the consulting company and each client.

Analysing the results of the ELECTRE Tri applications to the different scenarios, only three airport companies were marginally sensitive to the scenario choice, as they changed category only in one of the assignment procedures[1], but nine of the nineteen companies

[1] The second phase of the ELECTRE Tri application can adopt the pessimistic (or conjunctive) assignment procedure or the optimistic (or disjunctive) one, to assign the candidates to the sequential categories. When the decision maker is not involved or a preference system is not available the use of both the assignment procedures can support the critical analysis of the results and the testing of the modelling hypotheses.

were assigned to the less informative intermediate category. In order to obtain a better distinction of the performances, a new modelling hypothesis was tested eliminating the two biggest companies (Roma Fiumicino and Milano Malpensa), with values that are more European than Italian and the assignment to the highest category of performance in all the scenarios. The size of the used scales was reduced and some reference profiles that separate the categories were changed, together with some veto thresholds (some details of the procedure are described in 2.2). Two different variants of this new model were developed and the results of the ELECTRE Tri applications to the variants were not sensitive to the different scenarios. The changes from the previous model results were limited to three airports, while the three others which in that model were marginally sensitive to the scenario choice here resulted stably assigned to the High performance category in the two new variants of the model.

A tentative of parametric inference of the criteria importance and the cutting level was developed by the use of ETA, the ELECTRE Tri Assistant procedure of SW ELECTRE TRI 2.0 (Mousseau et al., 1999), in relation to the second model. The knowledge that the consulting company acquired in the process of model development and analysis of the ELECTRE Tri results made the application of ETA possible, in terms of an experiment of preference system inference without the support of the model structuring logic. Their few indications about the different importance of the criteria allowed us to introduce three constraints ($g_1,g_2>g_3,g_4,g_5,g_6,g_7$; $g_4,g_5>g_6,g_7$; $g_3>g_4,g_5$) and to eliminate any reference to the three scenarios. At the same time, some decision examples in relation to actual or hypothetical companies were introduced in the list of the assignment examples.

ETA calculated the "optimal" criteria importance in relation to a very high cutting level (0.78), with the greatest change (17%) in relation to the first criterion in the first scenario and a tendency to confirm the oriented to the investments scenario. But the results of this new (and different) weight variant were not so different from the others. The use of ETA was proposed because it could be very important for the future applications of ELECTRE Tri to the models, with the involvement of the decision makers.

2.2 Definition and use of the reference profiles

In relation to the first model, only three categories were defined, and linked to the dimension of the operational level of each airport (high, medium and small capability), as their number could be increased to four or five in order to better represent the result variations in the robustness analysis. The definition of the reference profiles that separate the categories was very simple for the criteria with ordinal scales, because of the logical definition of the evaluation states of the scales. For the cardinal scales an analysis of the evaluation distributions was adopted in order to identify some clear distinctions between situations and discussed with the problem owner. An example is described in figure 3 by means of the distribution of the evaluations of all the airports in relation to the criterion g5, Penetration of low-cost flights, that adopts as evaluation the percent of low-cost flights on total passenger flights. Penetration is between 4% and 98% and the values 12% and 32%

(that were used as reference profiles) are connected to the two curvature changes (or vertices) of the evaluation distribution.
The parameters that were used in all the applications of ELECTRE Tri are synthesized in table 10, the relative importance coefficients are proposed in table 8 and the evaluations of the airports in relation to the Capability model in table 11.

In relation to the second model, three categories were defined and linked to the whole performance of the company managing the airport system (good, intermediate and weak performance) and also in this case their number was increased to five after the robustness analysis. The evaluation distributions were essential, in the definition of the reference profiles that separate the categories, because all the criteria adopt cardinal scales and the consulting company was not able to indicate significant parameters. This distribution analysis was very useful also because it suggested the model variant without the biggest companies (see 2.1), in order to visualize a better distinction between situations. The parameters that were elaborated and discussed with the consulting company, for all the variants of the Performance model, are synthesized in table 12, where the changes are underlined by the italic format of the characters. The relative importance coefficients are proposed in table 9 and the evaluations of the companies in relation to the Performance model in table 13.

When all the parameters of the two models were defined and some variants identified (two in terms of weights for the first model and three weight scenarios plus the ETA weights for the second model; three model variants for scales, reference profiles and veto thresholds for the second model, with and without the biggest airports), the sensitivity of each variant was analysed in relation to the variation of the cutting level, in the interval 0.54 - 0. 76, and to the identified possible changes related to the other variants. In almost all the cases the assignments to the categories were confirmed and in the few other cases the changes resulted limited to the passage from a category to an adjacent one and always to the same. This analysis confirmed the model robustness and produced a clear representation of the results by means of five assignment categories.

The 21 airports of the first model were assigned to the original categories (3 to the High capability category, 11 to the Medium and 2 to the Low) and to two intermediate categories that the robustness analysis suggested (2 airports to the Medium-High and 3 to the Medium-Low).

The 19 companies managing the airport systems were assigned to the original categories (5 to the Good performance category, 5 to the Intermediate and 4 to the Weak) and to the two proposed by the analysis categories (2 to the Intermediate-Good and 3 to the Weak-Intermediate performance category).

2.3 Synthesis of the results

The scheme of table 14 was used to visualize the results of the ELECTRE Tri applications to the two models and to recognize the actual functioning level of each specific airport, in terms of non-aviation services. The performance of each airport, that resulted from the second model, is correlated by means of the scheme of table 14 with its capability level, that resulted from the first one. The actions assigned to the positions 4, 7 and 8 propose best practices because their performances are good or intermediate, in relation to capabilities that are only medium or low. When the actions are assigned to the positions 2, 3 and 6, the situation needs improvements and an analysis of the possible motivations could support the definition of possible strategies. The assignments to the positions 1, 5 and 9 are not so informative.

The two models present a different number of actions, 21 airports and only 19 companies. In the scheme (see table 15) that synthesizes the results from the two models, the actions are 19 for both the models and Rome and Milan correspond to the two airports of Rome and the two of Milan. The airports that present the worst situation are Cagliari, Lamezia, Treviso and then Bari, Genoa and Olbia. The best practices that can be used as references in the definition of new strategies are Catania, Verona, Naples and Turin (but the performance of the last airport is not so informative as it is partially related to the consequences of the Winter Olympic Games of 2006). Venice and Florence present interesting situations but their capabilities and results are heavily linked to so specific situations, of both the demand and the geographical characteristics of these airports, that they cannot be used as references. Also Bergamo, Bologna, Palermo and Pisa could improve their performances. The other assignments are not so informative.

Conclusions

The scheme that synthesizes the result of the ELECTRE Tri applications can be used to describe the Italian situation in terms of non-aviation service performance by the position of each specific airport in this whole scenario and its activation potentialities. The two models and the multiple criteria evaluations in relation to the models can be used to underline specific weakness points, activate a deeper analysis and orient a process of information acquisition. A collective reading of models and results can be used to reorganize these representations and/or to elaborate specific strategies with the aim of reducing weakness and attributing an adequate value to each potentiality.

Incremental procedures of model structuring and calibration, result analysis and model improvement allowed us to collectively elaborate interesting results and, above all, a procedural tool that can facilitate communication between the consulting company and their clients and activate new decision processes and innovation.

The elaboration of two different multiple criteria models allowed us to introduce MCDA language and procedures in a problem context that resulted well known for the consulting company, in order to later and easier focalize the critical one. At the same time the two models produce complementary results that can be synthesized in a clear and robust vision of the situation.

This incremental approach, that was used the first time in (Norese, 2009), can be generalized and used in several situations where the main challenge is the uncertainty level of an unstructured decision context that has to be identified and reduced before the use of a decision aiding method.

These applications of ELECTRE Tri are now under analysis by a laboratory team, in relation to the understanding of the different potentialities of the SW IRIS 2.0 (Dias and Mousseau, 2003) and the other ELECTRE Tri variants, such as the ELECTRE TRI-NC method (Dias et al., 2012).

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Table 1 – DIMENSIONS, *criteria* and scales or units of measurement for the first model

TRAFFIC MANAGEMENT

g_1 – Complexity of the traffic management

Ordinal scale from 1 to 13, in relation to the number of strips and handler, see table 2 for details

g_2 – National commercial traffic

Unit of measurement: aircraft takeoff/landing number per year towards or from national airports

g_3 – International commercial traffic

Unit of measurement: aircraft takeoff/landing number per year towards or from international airports

g_4 – Low-cost air links

Unit of measurement: number of links between the airport and all the other connected airports

g_5 – Penetration of low-cost flights

Unit of measurement: percent of low-cost flights on total passenger flights

AIR NAVIGATION SERVICES ON THE GROUND

g_6 – Quality of the boarding operations

Unit of measurement: average time for check-in plus security control

g_7 – Comfort of the permanence in the airport

Unit of measurement: perception of the comfort level (distribution %)

PUBLIC FACILITIES

g_8 – Essential services

Unit of measurement: number of bars, restaurants, car rentals, banks, cash dispenser machines, currency exchange offices.

g_9 – One brand shops

Ordinal scale from 1 to 8 (see table 3 for details)

g_{10} – Shops (that are not one brands)

Unit of measurement: number of shops (stores, hairdressers, bookshops, pharmacies, fitness centres, regional product shops)

ACCESSIBILITY

g_{11} – Information to the public

Unit of measurement: arithmetic mean between two ENAC indicators, "whole perception of information effectiveness" and "user perception of the traffic information signs" (% of satisfied passengers)

g_{12} –Accessibility to information by remote

Ordinal scale from 0 to 28, in relation to the presence/absence of information and the number of clicks that are required to obtain the main seven information elements that are accessible by the web site (see table 4 for details)

g_{13} – Accessibility by private vehicles

Ordinal scale from 1 to 7, in relation to the number of parking sites and different rates (see table 5 for details)

g_{14} - Accessibility by public transport systems

Ordinal scale from 1 to 7, in relation to the number of daily links by public transport with the city of reference and the distance in Km between the airport and the city (see table 6 for details)

Table 2 – Ordinal scale of the criterion g_1 as combination of handlers and strips number

Handlers / Strips	1	2	3	4	5	6
1	1	3	5	7	9	11
2	2	4	6	8	10	12
4	3	5	7	9	11	13

Table 3 – Ordinal scale of the criterion g_9

Value	Description
1	No one brand shop
2	Only one shop
3	From 2 to 4 shops
4	From 5 to 8
5	From 9 to 15
6	From 16 to 25
7	From 26 to 40
8	More than 40

Table 4 – Ordinal scale of the criterion g_{12}

Value	Description
0	Unavailable information
1	Three steps to find information
2	Two steps
3	One step
4	Information on the home page

Table 5 – Ordinal scale of the criterion g_{13}

Rates Parking sites	≦10	11-40	>40
<700	1	3	5
700-2000	2	4	6
>2000	3	5	7

Table 6 – Ordinal scale of the criterion g_{14}

Distance from the city Transport connections	>20	11-20	≦10
<100	1	2	3
100-200	3	4	5
>200	5	6	7

Table 7 – DIMENSIONS, *criteria* and units of measurement for the second model

ENTREPRENEURIAL SKILLS OF THE COMPANY (REVENUES FROM INVESTMENTS)
g_1* – *Sub-concessions   **Unit of measurement: Euros**
g_2* – *Advertising   **Unit of measurement: Euros**
g_3* – *Other proceeds **(above all from management of property and intellectual property)**   **Unit of measurement: Euros**
ANSWER TO THE DEMAND OF NON-AVIO SERVICES
g_4* – *Revenue from parking sites   **Unit of measurement: Euros**
g_5* – *Revenue from shopping   **Unit of measurement: Euros**
g_6* – *Car rental demand   **Unit of measurement: number of companies**
g_7* – *Catering demand   **Unit of measurement: number of bars, restaurants and other catering services**

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Unit of measurement: Euros
g_2* – *Advertising
Unit of measurement: Euros
g_3* – *Other proceeds **(above all from management of property and intellectual property)**
Unit of measurement: Euros

ANSWER TO THE DEMAND OF NON-AVIO SERVICES

g_4* – *Revenue from parking sites
Unit of measurement: Euros
g_5* – *Revenue from shopping
Unit of measurement: Euros
g_6* – *Car rental demand
Unit of measurement: number of companies
g_7* – *Catering demand
Unit of measurement: number of bars, restaurants and other catering services

Table 8 - Coefficients of relative importance (variants of the Capability model)

CRITERIA	Weights 1	Weights 2	Weights 3
g_1 Complexity of the traffic management	0,07	0,15	0,15
g_2 National commercial traffic	0,07	0,07	0,07
g_3 International commercial traffic	0,07	0,07	0,07
g_4 Low-cost air links	0,07	0,035	0,035
g_5 Penetration of low-cost flights	0,08	0,035	0,035
g_6 Quality of the boarding operations	0,08	0,08	0,08
g_7 Comfort of the permanence in airport	0,09	0,09	0,09
g_8 Essential services	0,09	0,09	0,11
g_9 One brand shops	0,05	0,05	0,04
g_{10} Shops (that are not one brands)	0,06	0,06	0,05
g_{11} Information to the public	0,05	0,05	0,05

g_{12} Accessibility to information by remote	**0,06**	**0,06**	**0,06**
g_{13} Accessibility by private vehicles	**0,07**	**0,07**	**0,06**
g_{14} - Accessibility by public transport systems	**0,09**	**0,09**	**0,10**

Table 9 – Coefficients of relative importance (scenarios of the Performance model)

CRITERIA	Weights 1	Weights 2	Weights 3
g_1 – Sub-concessions	**0,17**	**0,20**	**0,14**
g_2 – Advertising	**0,17**	**0,20**	**0,13**
g_3 – Other proceeds	**0,16**	**0,20**	**0,13**
g_4 – Revenue from parking sites	**0,13**	**0,10**	**0,15**
g_5 – Revenue from shopping	**0,13**	**0,10**	**0,15**
g_6 – Car rental demand	**0,12**	**0,10**	**0,15**
g_7 – Catering demand	**0,12**	**0,10**	**0,15**

Table 10 – Parameters of the Capability model: min and max values on the scales (bmin and bmax), values of the profiles (b1 an b2), thresholds of indifference (qj), preference (pj) and veto (vj) for the first and the second profile

CRITERIA	bmin	b1	qj	pj	vj	b2	qj	pj	vj	bmax
g_1 Complexity of the traffic managm.	1	2	0	0	0	6	0	0	5	13
g_2 National commercial traffic	3230	10000	100	300	0	31000	100	300	0	152085
g_3 International commercial traffic	907	9500	100	300	35000	30000	100	300	25000	214219
g_4 Low-cost air links	4	10	0	2	0	40	0	2	0	72
g_5 Penetration of low-cost flights	4	12	1	3	0	32	1	3	0	98
g_6 Quality of the boarding operations	37	26	0	3	0	15	0	3	0	8
g_7 Comfort of the permanence	75	85	3	6	0	93	3	6	0	99
g_8 Essential services	9	15	1	3	20	25	1	3	18	47
g_9 One brand shops	1	2	0	0	0	6	0	0	6	8
g_{10} Shops (that are not one brands)	2	8	1	3	0	15	1	3	13	36
g_{11} Information to the public	75	82	2	4	0	91	2	4	0	99
g_{12} Access. to information by remote	11	17	0	2	0	21	0	2	20	23
g_{13} Accessibility by private vehicles	1	3	0	0	0	5	0	0	4	7
g_{14}Accessibility by public transport	1	3	0	0	0	5	0	0	4	7

Table 11 – Evaluations of the airports in relation to the Capability model

Airport	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10	g11	g12	g13	g14
Rome Fiumicino	13	152085	157980	46	8	32	85	47	8	36	86	23	3	5
Milan Malpensa	10	33237	214219	47	9	30	90	36	8	31	92	23	3	3
Milan Linate	8	71506	28607	17	11	16	90	23	6	15	88	23	3	5
Venezia	6	25104	51934	45	25	30	98	25	6	11	92	18	5	4
Bergamo	2	9610	44131	72	85	17	86	22	3	12	90	19	7	7
Catania	1	41913	9223	49	32	25	90	24	1	4	90	11	4	3
Naples	3	31617	20952	35	24	20	99	13	2	9	99	22	6	5
Rome Ciampino	7	6065	34766	50	98	35	75	19	3	10	82	23	4	6
Palermo	2	37187	8005	38	30	19	96	19	1	7	95	19	4	5
Bologna	3	16326	39926	25	12	24	90	18	5	14	94	23	3	5
Pisa	4	9622	24393	53	67	13	92	23	3	9	90	22	4	7
Verona	1	13488	21491	14	7	29	87	17	3	2	88	17	5	2
Turin	1	20265	25036	7	10	37	86	19	4	9	85	21	7	4
Bari	3	18888	4769	24	26	10	96	15	3	9	86	22	5	3
Cagliari	2	23067	3786	12	6	10	92	12	3	11	81	17	5	3
Florence	1	7378	13971	5	4	29	80	12	3	8	80	17	2	3
Olbia	1	12586	7313	17	22	13	93	15	4	9	87	20	4	7
Treviso	3	3230	9103	18	97	36	96	9	2	4	97	17	6	5
Lamezia Terme	2	10952	2917	15	17	13	93	14	1	8	92	19	4	1
Genoa	1	11688	6574	4	17	22	88	15	2	6	84	19	4	3
Brindisi	2	7386	907	10	31	8	98	9	1	5	75	22	1	3

Table 12 - Parameters of the Performance model: min and max values on the scales, values of the profiles b1 an b2, thresholds of indifference, preference and veto for the first and the second profile

CRITERIA	bmin	b1	qj	pj	vj	b2	qj	pj	Vj	bmax
g_1 Sub-concessions	400	865	1	20	6000	5500	1	20	5500	120108
g_2 Advertising	259	1200	1	20	1000	1900	1	20	1900	14479
g_3 Other proceeds	129	1800	1	40	3000	4200	1	40	4200	41365
g_4 Revenue from parking sites	459	3000	100	200	7000	9000	100	200	8000	47224
g_5 Revenue from shopping	1040	2300	100	200	8000	9000	100	200	8000	96015
g_6 Car rental demand	1	3	1	3	13	8	1	3	7	36
g_7 Catering demand	4	6	1	3	8	10	1	0	9	26

Initial values

CRITERIA	bmin	b1	qj	pj	vj	b2	qj	pj	vj	bmax
g_1 Sub-concessions	400	865	1	20	6000	*4000*	1	20	*4000*	*9500*
g_2 Advertising	259	*940*	1	20	1000	*1400*	1	20	*1400*	*2000*
g_3 Other proceeds	129	*1700*	1	40	3000	*4000*	1	40	*3000*	*7000*
g_4 Revenue from parking sites	459	*2900*	100	200	7000	*7000*	100	200	*5000*	*12000*
g_5 Revenue from shopping	1040	*3500*	100	200	8000	9000	100	200	8000	*37000*
g_6 Car rental demand	1	3	1	3	13	*7*	1	3	*6*	*10*
g_7 Catering demand	4	6	1	3	8	*9*	1	0	*8*	*18*

First variant

CRITERIA	bmin	b1	qj	pj	vj	b2	qj	pj	vj	bmax
g_1 Sub-concessions	400	865	1	20	*4500*	*4000*	1	20	*4000*	*9500*
g_2 Advertising	259	*940*	1	20	*550*	*1400*	1	20	*1400*	*2000*
g_3 Other proceeds	129	*1700*	1	40	3000	*4000*	1	40	*3000*	*7000*
g_4 Revenue from parking sites	459	*2900*	100	200	*5000*	*7000*	100	200	*5000*	*12000*
g_5 Revenue from shopping	1040	*3500*	100	200	*7000*	*9600*	100	200	*9000*	*37000*
g_6 Car rental demand	1	3	1	3	13	*7*	1	3	*6*	*10*
g_7 Catering demand	4	6	1	3	8	10	1	0	9	*18*

Second variant

Table 13 – Evaluation of the companies in relation to the Performance model

Company	g1	g2	g3	g4	g5	g6	g7
ADR Fiumicino Ciampino	120108	2698	24317	30050	96015	36	20
SEA Malpensa Linate	38390	14479	41365	47224	56808	20	26
SAVE Venezia	4009	1825	5990	10080	35330	7	11
SACBO Bergamo	2552	703	4117	7033	15481	6	8
SAC Catania	4651	1047	2386	1634	3091	4	17
GESAC Naples	6622	1942	5003	8092	13244	6	4
GESAP Palermo	405	1157	1785	2999	1911	8	5
SAB Bologna	2636	1721	1806	10514	9642	7	8
SAT Pisa	864	1101	4309	3883	7426	9	11
AVC Verona	8518	1751	1705	5772	2325	9	5
SAGAT Turin	8639	1938	4573	7519	3964	4	10
ADP Bari	780	936	4921	2067	2028	4	9
SOGAER Cagliari	800	1216	246	4606	1921	4	5
ADF Florence	2239	1571	1876	2294	2534	3	6
GEASAR Olbia	5411	1031	129	1546	3092	6	6
AERTRE Treviso	426	460	166	529	5514	1	5
SACAL Lamezia Terme	416	360	1076	956	1155	3	9
ADG Genoa	5284	259	3074	459	2321	5	7
ADP Brindisi	400	480	561	1060	1040	2	6

Table 14 – Logical combination of the ELECTRE Tri results in relation to two models and their categories

Categories of *performance* / *Capability*	Good	Intermediate	Weak
High	**1**	**2**	**3**
Medium	**4**	**5**	**6**
Low	**7**	**8**	**9**

Table 15 - Synthesis of the results

Performance / Capability	Good	Good Intermediate	Intermediate	Weak Intermediate	Weak
High	**Milan Rome**				
Medium High	**Venice**				
Medium	**Naples Turin**		**Bergamo Bologna Palermo Pisa**	**Bari Genoa Olbia**	**Cagliari Lamezia**
Medium Low		**Catania Verona**			**Treviso**
Low			**Florence**		**Brindisi**

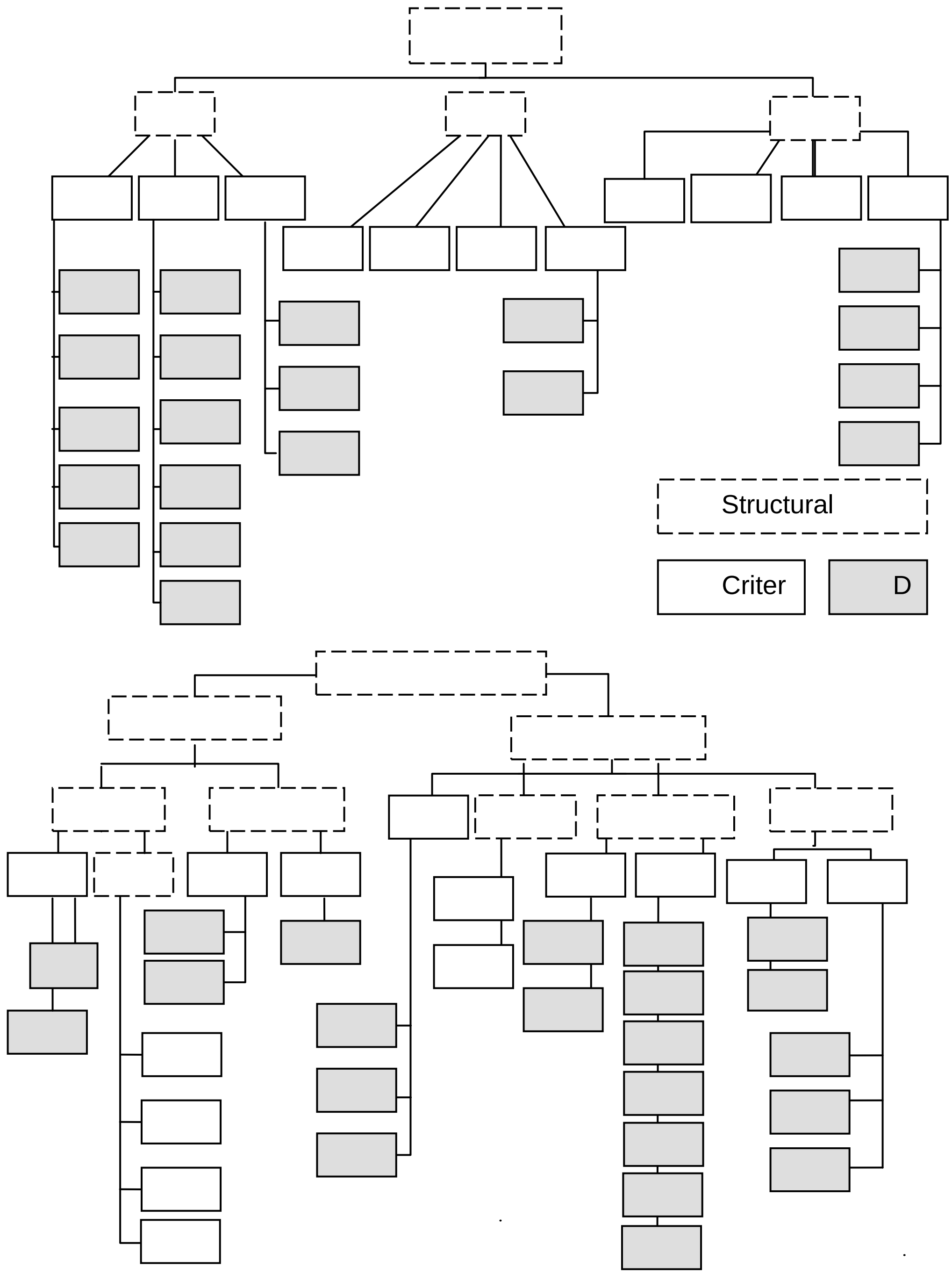

Figure 1 – The second and the last structure of the Capability model

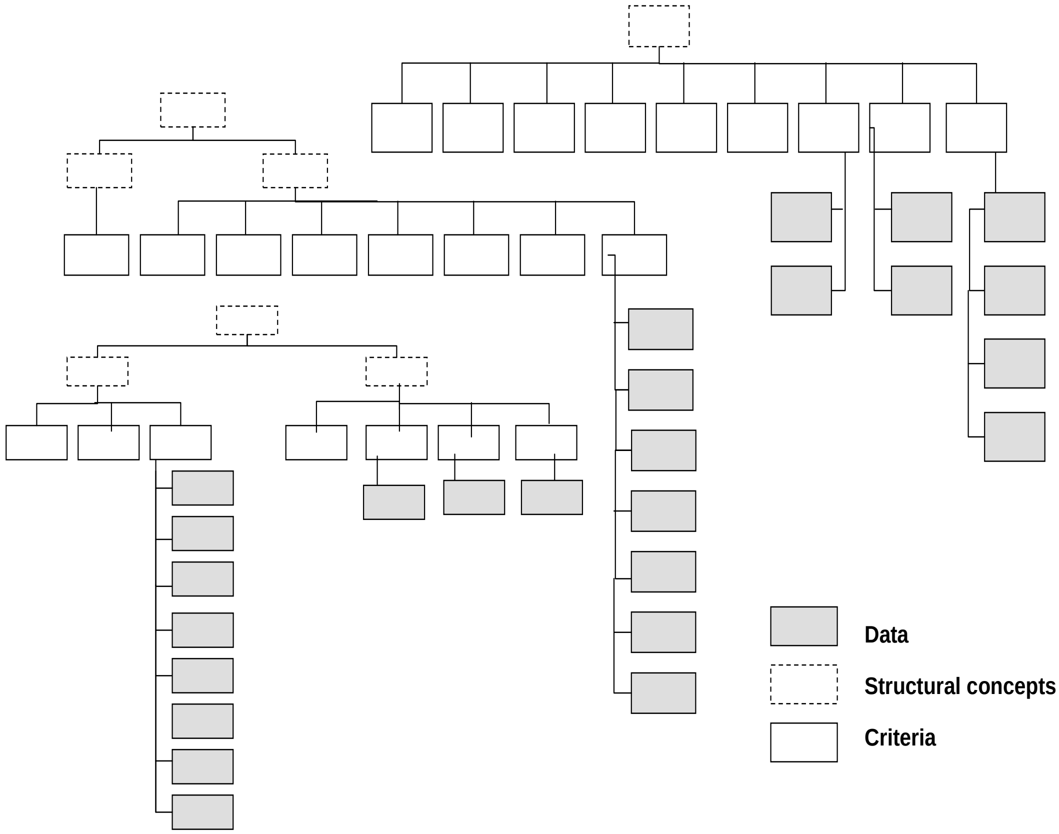

Figure 2 – The three structures of the model Performance

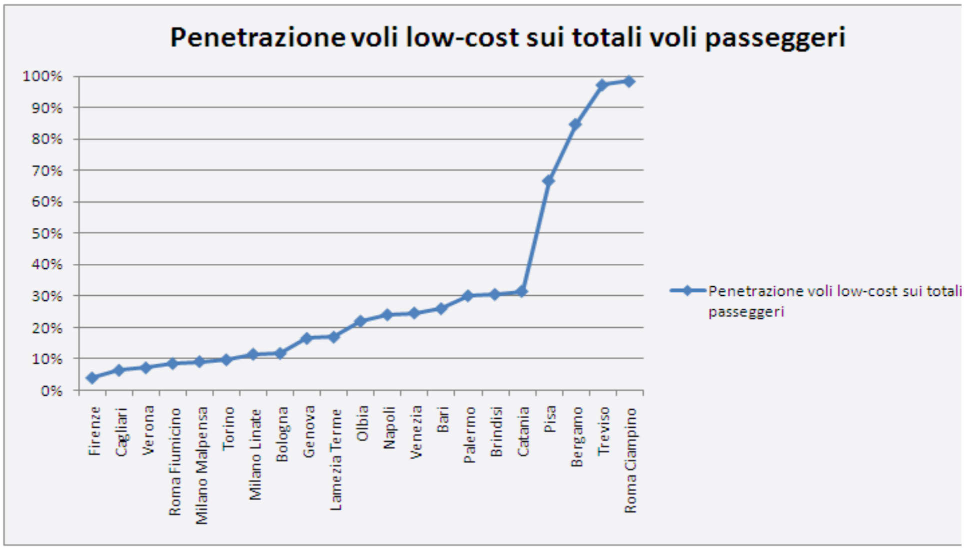

Figure 3 – Distribution of the airport evaluations in relation to the criterion g_5

Categories of *Performance* *Capability*	Good	Intermediate	Weak
High	**1**	**2**	**3**
Medium	**4**	**5**	**6**
Low	**7**	**8**	**9**

Figure 4 – Logical combination of the ELECTRE Tri results in relation to two models and their categories